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METHOD AND DEVICE FOR MANUFACTURING LIQUID CRYSTAL DISPLAY ELEMENT

[Abstract]

PROBLEM TO BE SOLVED: To enable adaptation to a large size to be required in future by improving display quality by increasing the alignment precision, gap precision, and in-gap-surface uniformity between a couple of substrates having liquid crystal between them.

SOLUTION: In a variable pressure tank 8, a lower surface plate 10 which can freely be displaced in the horizontal direction while mounted with one substrate 2a, an upper surface plate 9 which can freely be displaced in the vertical direction while sucking the other substrate 2b, and a linear actuator 13 which drives the upper surface plate are installed. On the substrate 2a, a seal pattern sealing the liquid crystal is formed and liquid crystal is dripped by an amount which is large

enough to fill a cell gap. On the substrate 2a or the other substrate 2b, spacers which prescribed a cell gap are scattered. In a pressure-reduced atmosphere, the upper surface plate 9 is displaced by the linear actuator 13 to bring one end part of the substrate 2a into contact with the substrate 2b and in this contact state, the upper surface plate 9 is turned to make the entire surface of the substrates come into contact with each other and then both the substrates are pressed and laminated together.

[Claims]

[claim 1] A method for fabricating a liquid crystal display device comprising: forming a seal pattern for sealing liquid crystals on a display electrode forming surface of one of a pair of substrates each having a display electrode, and simultaneously dropping or applying liquid crystals of an amount large enough to fill up a cell gap; dispersing spacers or installing a protrusion on the display electrode forming surface of one of the substrates, both the spacer and the protrusion prescribing a cell gap; installing the display electrode forming surfaces of the pair of substrates to face each other in a pressure-reduced atmosphere; bringing one end portion of one substrate into contact with another substrate and in this contact state, turning one substrate to make the entire surface of the substrates come into contact with each other; pressing and attaching the substrates together.

[Claim 2] The method of claim 1, wherein forming the seal pattern comprises: forming not only a seal pattern for sealing liquid crystal but also a seal pattern which encompasses the seal pattern without any discontinued portions.

[Claim 3] The method of claim 1 or 2, wherein both substrates are aligned before one end portion of one substrate comes in to contact with another substrate.

[Claim 4] The method of claim 1 or 3, wherein after the entire surfaces of the substrates contact with each other, both the surfaces are aligned and then pressed and attached together.

[Claim 5] An apparatus for fabricating a liquid crystal display device is an apparatus that forms a seal pattern for sealing liquid crystals on a display electrode forming surface of one of a pair of substrates each having a display electrode, simultaneously drops or applies liquid crystal of an amount large

enough to fill up a cell gap, disperses spacers prescribing a cell gap or installs a protrusion on the display electrode forming surface of one of the substrates, and presses and attaches the pair of substrates together with their display electrode forming surfaces facing each other, and comprises within a variable pressure tank, a lower surface plate which can be freely displaced in a horizontal direction while mounted with one substrate, an upper surface plate which can be freely displaced in a vertical direction while sticking with the other substrate, and a linear actuator which drives the upper surface plate, wherein in a pressure-reduced atmosphere, the upper surface plate is displaced by the linear actuator to bring one end portion of one substrate into contact with the other substrate and in this state, the upper surface plate is turned to make the entire surface of the substrates come into contact with each other and then both the substrates are pressed and attached together.

[Claim 6] The apparatus of claim 5, wherein a buffer material is installed between one substrate and the lower surface plate.

[Claim 7] The apparatus of claim 6, wherein before one end portion of one substrate contacts with the other substrate, the lower surface plate is displaced to perform the alignment for both substrates.

[Claim 8] The apparatus of claim 5 or 7, wherein after the entire surface of the pair of substrates contact with each other, both substrates are aligned and then pressed and attached together.

[Title of the invention]

Method and apparatus for fabricating a liquid crystal display device

[Detailed Description of the Invention]

[Field of the Invention]

The present invention relates to a method and apparatus for fabricating a liquid crystal display device used as an image display device such as a personal computer, a TV set and the like.

[Description of the Prior Art]

In a process of fabricating a liquid crystal display device in accordance with the prior art, as a method for encapsulating a liquid crystal material in a liquid crystal cell, there are an injection method and a dispensing method. The injection method is generally used for mass production. In the injection method, in a vacuum state, a liquid crystal material is injected from an aperture portion of an empty cell forming a gap formed by laminating a pair of substrate by a capillary phenomenon and a pressure differential. In the dispensing method, a liquid crystal material is dispensed onto one substrate and then the substrate is laminated to the other substrate in a vacuum state. Both the methods include a process of laminating the pair of substrates together, thereby completing a liquid crystal panel.

Figure 6 is a view which illustrates processes of fabricating a liquid crystal display (LCD) device according to the injection method in accordance with the prior art. Also, the LCD device 1 fabricated by such a method has a sectional structure shown in Figure 5. Spacers 4 are dispersed into the gap so as to form a predetermined gap between a pair of substrates 2a and 2b having display electrodes 5a and 5b therein, and the gap is filled up with the liquid crystal material 3. Polarization plates (not shown) or other optical films are installed at optimum portions of both outer sides of the pair of substrates 2a and 2b. One or two polarization plates may be used or no polarization plate may be used according to a principle mode.

If the LCD device 1 having the aforementioned structure is a backlit LCD device, light is irradiated from a side opposite to a display surface by a three wavelength cold cathode ray tube and is displayed. If the LCD device is a reflective LCD device, a reflection plate is installed at a side opposite to a display surface and therefore uses external light, thereby implementing brighter display.

A method for fabricating the LCD device 1 according to the prior art will now be described with reference to the view of Figure 6. In the injection method, the substrates 2a and 2b having the display electrodes 5a and 5b are washed, a liquefied alignment material is applied by an offset printing or the like and temporary baking and main baking are performed to form an alignment film 7, and an alignment process is performed thereon by rubbing or the like. In general, after the rubbing, water washing is performed in order to remove foreign substances or uncleanness of the substrate.

Then, a sealant 6 for sealing liquid crystal is applied on one substrate, for example, on a substrate 2a, by a patterning device, a screen stencil or the like, thereby forming a seal pattern. Also, spot printing of the UV resin for temporary fixation (tacking) is carried out by a dispenser or the like outside a region of the LCD device 1. In order to form a gap, spacers 4 having predetermined size are dispersed on the other substrate 2b, and both substrates 2a and 2b are laminated (attached) together in the atmospheric air. At the time of attachment, it is set to recognize optically alignment marks prepared on electrodes of both substrates 2a and 2b. Then, when the alignment marks coincide with each other, ultraviolet rays are irradiated to the UV resin for the temporary fixation (tacking) to thereby harden the UV resin.

In order to perform gap control of the LCD device 1, a pair of substrates

2a and 2b are entirely pressurized by air pressure or the like, and when an optimum gap is formed, the sealant 6 is hardened. Here, if a thermosetting sealant is used, the hardening of the sealant 6 is made by applying heat thereto using a heater wire provided in a surface plate for the air press (not shown). If the sealant is hardened by UV, a method of hardening the sealant 6 by using a transparent thick surface plate made of glass, acryl or the like as a surface plate performing the air press and irradiating UV from the outside of the surface plate when an optimum gap is formed is commonly used.

Then, a glass portion besides a substrate display region is cut out. As for the injection method, those obtained by pooling the empty cell made in the aforementioned manner and liquid crystal 3 are put in a vacuum tank. Then, with pressure of about 26~93Pa(or 0.2~0.7Torr), an inlet of the empty cell contacts with the liquid crystal, the inside of the vacuum tank is exposed to the atmospheric air and the liquid crystal 3 is filled in the empty cell. Then, the inlet is closed by resin or the like, the liquid crystal 3 attached to the LCD device 1 is washed, then, the entire LCD device is annealed, and a re-alignment process is performed on the liquid crystal 3.

[Problems to be solved by the Invention]

The method for fabricating an LCD device 1 in accordance with the related art uses air press or UV press to obtain an optimum gap in the making of the empty cell. However, this method has problems in that neither sufficiently high precision in alignment nor evenness of gap sides cannot be obtained. Also, because a size of a substrate will be bigger in the future, how to achieve the high precision processes becomes issues.

Namely, an attachment method for fabricating the LCD device in

accordance with the related art has the following problems in improving precision of the alignment of a pair of substrates and optimizing gap precision. First, because an alignment process and a pressurizing press process for forming a gap are separated, a proper empty cell is not made. Namely, an assembly operation cannot be properly made because a UV resin for the temporary fixation in the alignment process is detached by a force of the pressurizing press during the following process and alignment precision of markers formed on the pair of substrates exceed the desired width.

Also, although a pair of substrates are attached with the high alignment precision and temporarily fixed, the alignment position may be shifted and thus sufficient alignment precision cannot be obtained. This is because in the following seal hardening process, the sealant is thermosetting and a difference in a linear expansion coefficient between a pair of substrates made of glass and a sealant inserted therebetween exists over a time for heating press and by a temperature change of the LCD device. Also, this problem gets worse as substrates get bigger.

If UV resin is used as the sealant, UV light is irradiated from the outside of a transparent surface plate in a state that a gap has already formed by a pressurizing press. However, as operations are performed several times, the surface plate is heated by radiant heat due to the UV light irradiation and a temperature of the surface plate itself raises. For this reason, a heat is applied only to one substrate which is in contact with the surface plate while no temperature change occurs at the other substrate, which leads to a temperature difference between the pair of substrates. In such a state, if the sealant between the pair of substrates is hardened by the UV light irradiation, the aligned substrates are bent and therefore gap ununiformity occurs in the LCD device. This

problem is also worsened as sizes of substrates get bigger.

As mentioned above, the fabricating method in accordance with the prior art cannot cope with a future substrate size enlargement while meeting the sufficient alignment precision and gap precision.

The present invention solve the problems of the prior art while coping size enlargement of a substrate of about 20 types of liquid crystal display devices called for by an LCD monitor which is an alternative of CRT etc. Also, the present invention aims at providing a method and apparatus for fabricating an LCD device capable of improving alignment precision, enabling fabrication of a bright display device with a large aperture ratio, offering highly precise formation of a narrow gap, improving evenness of gap sides and realizing a high-definition display.

[Means for Solving the Problem]

In order to attain the aforementioned object, there is provided a method for fabricating a liquid crystal display device comprising: forming a seal pattern for sealing liquid crystal on a display electrode forming surface of one of a pair of substrates each having a display electrode and simultaneously dropping or applying liquid crystal of an amount large enough to fill up a cell gap; dispersing spacers prescribing a cell gap or installing a protrusion on the display electrode forming surface of one of the substrates; installing the display electrode forming surfaces of the pair of substrates to face each other in a pressure-reduced atmosphere; bringing one end portion of one substrate into contact with another substrate and in this contact state, turning one substrate to make the entire surface of the substrates come into contact with each other; pressing and attaching the substrates together.

In order to attain the aforementioned objects, there is provided an

apparatus for fabricating a liquid crystal display device is an apparatus that forms a seal pattern for sealing liquid crystal on a display electrode forming surface of one of a pair of substrates each having a display electrode, simultaneously drops or applies liquid crystal of an amount large enough to fill up a cell gap, disperses spacers or installs a protrusion on the display electrode forming surface of one of the substrates, both the spacer and the protrusion prescribing a cell gap and presses and attaches the pair of substrates together with their display electrode forming surfaces facing each other, and comprises within a variable pressure tank, a lower surface plate which can freely be displaced in a horizontal direction while mounted with one substrate, an upper surface plate which can be freely be displaced in a vertical direction while sucking the other substrate, and a linear actuator which drives the upper surface plate, wherein in a pressure-reduced atmosphere, the upper surface plate is displaced by the linear actuator to bring one end portion of one substrate into contact with the other substrate and in this state, the upper surface plate is turned to make the entire surface of the substrates come into contact with each other and then both the substrates are pressed and attached together.

By the method and apparatus for fabricating an LCD device, the precision of alignment and evenness of cell gap sides are improved because an alignment process and a gap control process are not separated unlike the related art but are performed in a series of processes in an atmosphere where the pressure is properly adjusted.

[Embodiment of the Invention]

An embodiment of the present invention will now be described in detail with reference to the accompanying drawings. Figure 1 shows a sectional

structure of an LCD device fabricated by a fabrication method according to one embodiment of the present invention. Spacers 4 are distributed to form a predetermined gap between a pair of substrates 2a and 2b having display electrodes 5a and 5b therein, and a liquid crystal 3 is filled in the gap. Polarization plates or other optical films (not shown) are provided at optimum portions of both outer sides of the pair of substrates 2a and 2b. The substrates 2a and 2b include a color filter substrate, an array substrate in which an active device is arranged and a substrate having a transparent electrode.

Moreover, the spacer 4 may has a spherical shape or a bar shape and be formed of resin such as benzonkuanamin or SIO_2. Also, to improve the gap uniformity, the spacer 4 may be fixed to the substrates 2a and 2b. A sealant 6 is applied around the LCD device 1. As types of the sealant 6, there are a thermosetting type made of epoxy resin and a UV-hardened type such as radial, cation or the like.

A method for fabricating the LCD device 1 will now be described with reference to the flow chart of Figure 2. A liquefied alignment material is formed by off-set printing on the substrates 2a and 2b having passed through a washing process and is dried at a high temperature, thereby forming an alignment film 7. A surface of the alignment film on the substrate is rubbed with a buff, and if there are foreign substances on the surface, a washing process is performed thereon. Then, a sealant 6 is applied to the substrate 2a by patterning or printing, and spacers 4 are uniformly scattered on the other substrate. UV resin of a radical or cation type is used as the sealant 6. Also, a fixed type spacer is used as the spacer 4, and such a spacer 4 requires a certain amount of adhesive force with respect to the substrate 2b. And, conductive resin is applied by the dispenser as if being

scattered.

Then, the liquid crystal 3 is dropped. Preferably, the liquid crystal 3 is dropped on the substrate 2a on which the sealant 6 has been applied. The amount of liquid crystal 3 dropped can be pre-calculated by a display area and a gap thickness of the LCD device 1. After preparing a pattern for the uniform dropping of the liquid crystal 3, the liquid crystal 3 having been degassed is dropped.

Then, both the substrates 2a and 2b are attached together by using an assembly method in accordance with the present invention. Figure 3 is a schematic view which illustrates an outline of a substrate attachment device and its attaching method which can implement the method for fabricating the LCD device in accordance with the present invention. After the conductive resin is applied to the substrate 2a or 2b, those substrates 2a and 2b are loaded thereon and attached. The attachment device has a pair of upper and lower surface plates 9 and 10 within a variable pressure tank 8. A relative position in a vertical direction to the lower surface plate 10 and a parallelism of the upper surface plate 9 can be controlled by operation of a linear actuator 13. The lower surface plate 10 may be displaced in a horizontal direction so as to perform the alignment. Also, although not shown in the drawing, a recognition camera for alignment is installed within the device.

One of the substrates, for example, the substrate 2a is installed on the lower surface plate 10 with a buffer material 12 therebetween, the other substrate 2b is sucked to the upper surface plate 9, and then the inside of the variable pressure tank 8 is adjusted to be at the predetermined pressure. Then, a clearance of the substrates 2a and 2b is adjusted to a predetermined value by the linear actuator 13. Accordingly, alignment is carried out with necessary precision,

checking position correspondence of markers of the substrates 2a and 2b.

Then, the linear actuator 13 brings one end of one substrate 2a into contact with another substrate 2b, and in the contact state, the upper surface plate 9 is turned and lowered on the basis of the contacted portion to make the entire surface of the substrates come into contact with each other. Also, by checking the position correspondence of the marks of the substrates 2a and 2b, the alignment is made with desired precision. Thereafter, the upper and lower surface plates 9 and 10 are pressurized to attach both the substrates 2a and 2b, and the inside of the variable pressure tank 8 returns to the atmospheric pressure.

By the method of using the linear actuator 13, a contact position between the sealant 6 formed on the substrate 2a and the substrate 2b can be controlled by micron order, and as the contact starts from one end portion of the substrate slowly to the entire surface, no atmospheric air or a just small amount of the atmospheric air within the variable pressure tank 8 sealed inside the sealant 6 remains. Accordingly, air bubbles does not remain although pressure of the variable pressure tank 8 is about 150~200Pa. Also, the alignment with the high precision can be made through two steps of alignment. In addition, even if a precision stage or the like that can make minute operation with high degree of accuracy, the same effectiveness is acquired.

Thereafter, the sealant between both substrates 2a and 2b are hardened or temporarily hardened, thereby forming an LCD device 1. To this end, there are masking, a laser light exposure, etc. Finally, a re-alignment processing of the liquid crystal 3 is performed in an anneal process, and the substrates 2a and 2b are cut to make an LCD device 1.

Although a pattern is formed by a sealant in the present invention,

patterning by a dispenser or printing using a screen plate is more common. The seal pattern shown in Figure 4 is well used, a seal pattern 11 to be thrown away is formed outside a sealant 6 for sealing the liquid crystal, to achieve uniformity of a gap. In the present invention, because the attachment is made within a vacuum tank, a seal pattern which can further obtain the uniformity surrounds the LCD device 1 one time, an empty cell part can maintain a vacuum state although the inside of the variable pressure tank 8 of the assembly device returns to the atmospheric pressure, and evenness within the gap side can be improved. Also, in order to make an empty cell by hardening a sealant, the empty cell part remains in a vacuum state until the substrate is divided and cut.

[Effect of the Invention]

As explained above, according to this invention, by the new manufacture method, a high-definition liquid crystal display device that achieves improvement in the alignment precision of a liquid crystal display component, the evenness within a gap side, and gap precision can be produced. Without separately performing an alignment process and a gap control process like the prior art, the two process are carried out within the same continuous process, and inconvenience generated secondarily is eliminated. Thus, the misalignment due to the formation of a gap does not occur, and a mass-production property can be improved, without generating the bending of the LCD device.

Since an attachment process and a dropping process of an pre-calculated amount liquid crystal are carried out within a variable pressure tank, a higher gap precision is acquired and therefore, a future large sized substrate or narrow gap can be implemented.

Moreover, a liquid crystal dropping method is preferable in building a line

efficient for tack and read time, and a minimum amount of liquid crystal may be used.

[DESCRIPTION OF DRAWINGS]

Figure 1 is a sectional view of an LCD device fabricated by a fabrication method in accordance with one embodiment of the present invention;

Figure 2 is a flow chart which illustrates a fabrication method of the LCD device in accordance with one embodiment of the present invention;

Figure 3 is a schematic view which illustrates a structure and method of a substrate attachment device in accordance with one embodiment of the present invention;

Figure 4 is a view which illustrates a seal pattern in accordance with one embodiment of the present invention;

Figure 5 is a sectional view of an LCD device fabricated in a fabrication method in accordance with the related art; and

Figure 6 is a flow chart which illustrates a fabrication method of the LCD device in accordance with the related art.